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REPORT #
RRTAC 87-4

Reclamation Research Annual Report — 1986

Heritage Fund

Alberta

LAND CONSERVATION AND
RECLAMATION COUNCIL
Reclamation Research
Technical Advisory Committee

RECLAMATION RESEARCH
ANNUAL REPORT
1986

by

The Reclamation Research Technical Advisory Committee

for the

LAND CONSERVATION AND RECLAMATION COUNCIL

RRTAC Report 87-4

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1. INTRODUCTION

The regulation of surface disturbances is the responsibility of the Land Conservation and Reclamation Council. The Council executive consists of a chairman from the Department of the Environment and two deputy chairmen from the Department of Forestry, Lands and Wildlife. Among other functions, the Council oversees programs for reclamation of abandoned disturbances and reclamation research. The reclamation research program was established to identify the most efficient methods for achieving acceptable reclamation. Funds for implementing both the operational and research programs are drawn from Alberta's Heritage Savings Trust Fund.

To assist in technical matters related to the development and administration of the research program, the Council appointed the Reclamation Research Technical Advisory Committee (RRTAC). The Committee first met with March 1978 and consists of eight members representing the Alberta Departments of Agriculture, Forestry, Lands and Wildlife, Environment and the Alberta Research Council. The Committee meets regularly to update research priorities, review solicited and unsolicited research proposals, arrange workshops and otherwise act as a referral and co-ordinating body for reclamation research.

RRTAC develops reclamation research under four major program areas, which correspond to Alberta's major industrial activities and biophysical regions:

1. Plains Coal Reclamation Research Program
   - Work is focused on disturbances to agricultural lands of the plains caused by coal mining for electrical power generation.
2. Mountain Foothills Reclamation Research Program
   - This program addresses disturbances in predominantly forested areas of the mountains and foothills caused by metallurgical and high quality thermal coal mines.
3. Oil Sands Reclamation Research Program
   - Work in this program includes reclamation research on disturbances caused by oil sands developments in the northeastern portion of the province.

4. Oil and Gas Reclamation Research Program

   - This program area is concerned with oil and gas related developments such as pipelines and drilling activities, which are widely distributed throughout the province.

While it is expected that research results will often have province-wide application, the division of the program among the three biophysical regions has proven helpful in identifying priorities and directions for the research program.

RRTAC research projects are trials for new technologies, and new proposals are reviewed and rated on their adherence to priorities, likelihood of success and competence of researchers. Throughout the review process, the key question is: "Would this technology make reclamation in Alberta a more efficient process?"

Upon project completion a final report is submitted. Some final reports are published intact as RRTAC reports and released to the public. Others are held pending their inclusion in more comprehensive RRTAC reports. Section 3.6 provides a listing of available reports.

Additional information on the Reclamation Research Program may be obtained by contacting:

Dr. Glen Singleton, Chairman
Reclamation Research Technical Advisory Committee
14th Floor, Standard Life Centre
10405 Jasper Avenue
EDMONTON, Alberta
T5J 3N4

2. THE RESEARCH PROGRAM

Following is a summary of the most recent research projects as of March 31 1987. Budget details are given in Section 3.2. Information on previous projects is given in Section 3.1 and in previous annual reports.

2.1 PLAINS COAL RECLAMATION RESEARCH PROGRAM

The Plains Coal Reclamation Research Program (PCRRP) has been designed by the provincial government and members of the coal industry to answer questions relating to groundwater and soil reconstruction in plains coal mining zones. Efforts are focussed in two main areas:

1. Soil reconstruction will indicate how to rebuild agricultural soils after mining, and
2. Hydrology will describe what happens to groundwater during mining and after reclamation, and how to rebuild the landscape to maximize the agricultural potential.

The program has been jointly designed and managed by the provincial government and coal industry personnel. The projects are also funded by both industry and government. For example, Alberta Power Limited, Luscar Ltd., Manalta Coal Ltd. and TransAlta Utilities Corporation constructed the test plots at the Battle River and Highvale sites while research and maintenance activities for the Soil Reconstruction and Hydrology projects are supported by the provincial government.

2.1.1 Reclamation Objectives

To return crop land to pre-mining levels of capability. Capability includes both agricultural and hydrologic capabilities.

2.1.2 The Problem

Coal is surface mined in two major zones in Alberta: the Ardley Zone running southeast from Mayerthorpe to Red Deer and the Horseshoe Canyon Zone which runs parallel and to the east from Barrhead through Camrose to Drumheller (Figure 1). The Ardley Zone is surface mined near Lake Wabamun to provide coal to the Wabamun, Sundance, and Keephills power plants. An

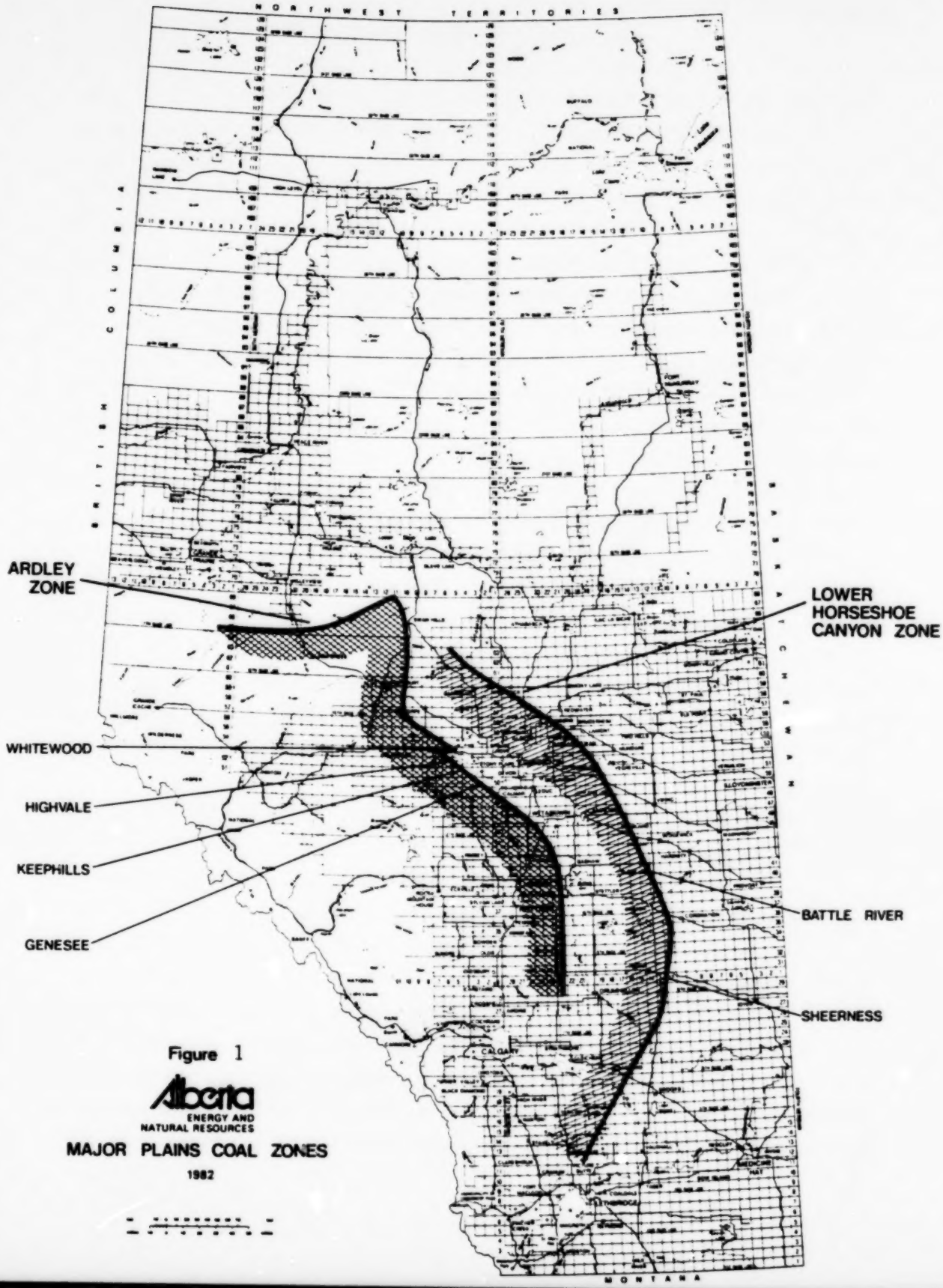


Figure 1

Alberta
ENERGY AND NATURAL RESOURCES

MAJOR PLAINS COAL ZONES

1982

additional power plant, Genessee, is under construction and will extend mining southward to the town of Genessee. The Horseshoe Canyon Zone is mined on either side of the Battle River between Forestburg and Halkirk. These mines supply the Battle River Generating Station. Another power plant and mine have been developed to the south of Sheerness.

Plains coal seams are usually overlain by bedrock which contain a high proportion of swelling clays. When exposed to the elements, the bedrock shales and sandstones break down into a material that is sticky when wet and very hard when dry. This severely hinders plant growth and agricultural operations. Above the bedrock lie glacial deposits which are usually free of the most adverse properties of the bedrock though they lack the plant nutrients and organic matter which are characteristic of the overlying topsoil.

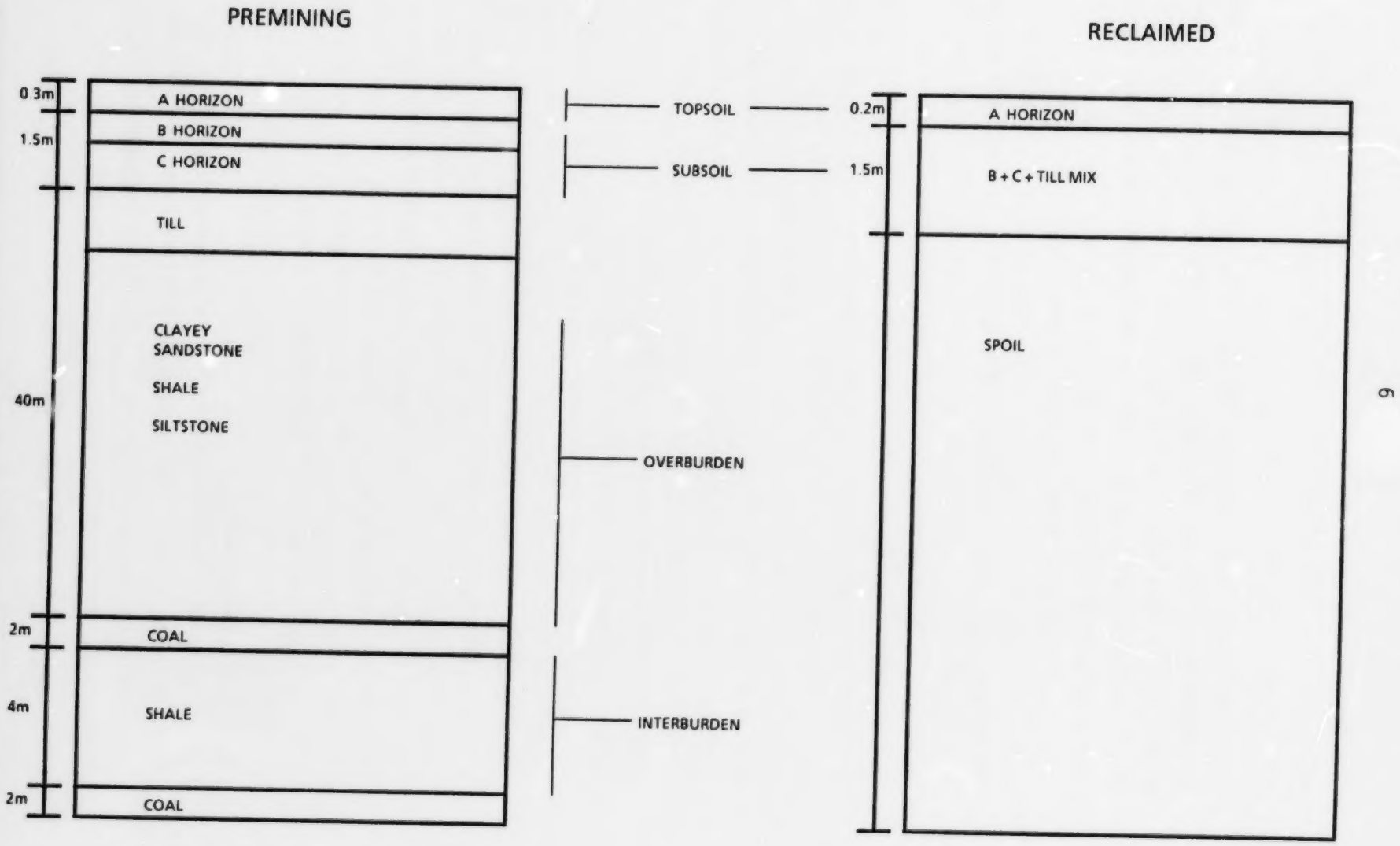
Rebuilding a soil profile is one of the major problems in cropland reclamation in Alberta. A soil must be built on levelled overburden which will have similar capability to the original soil. Existing evidence indicates that placing topsoil and a buffering material over the spoil is the most efficient method for achieving this goal (Figure 2). However, we do not know exactly how much capping material is needed in order to bring back the original level of agricultural capability. Also, when topsoils or subsoils are in short supply, other amendments may be useful in soil building. In addition to soil reconstruction, certain agricultural practices like green manuring and legume cropping may help rebuild the soil.

In many plains areas, the coal seams are the major source of domestic water. What will happen when the coal is removed and overburden fills the mined-out pit? The behaviour of the post-mining groundwater system will affect water users and could influence future agricultural potential. However, prior to the Reclamation Research Program little was known about the effects of surface mining on groundwater in Alberta.

2.1.3 Research Approach

Mining in the Ardley and Horseshoe Canyon Coal zones involves two different sets of soils, overburden and climate. Also, soil reconstruction and groundwater cannot be studied in isolation. For example, if after mining,

FIGURE 2 - GENERALIZED PROFILES



a saline watertable re-establishes within a foot of the soil surface, the topsoil, regardless of its original quality, will quickly become unsuitable for crops. In both the Ardley and Horseshoe Canyon zones the best methods of reconstructing soils are being identified and at the same time, mining effects on groundwater are being studied.

By combining the results of these experiments, we will develop a picture of how mined landscapes work and how they can be designed to ensure the return to their original value.

These projects are installed both at the Highvale and Battle River mining areas. Both are designed for five years of intensive study with the possibility for further monitoring beyond that period.

2.1.4 Soil Reconstruction

Battle River Soil Reconstruction Project - (82-5-LES) - L. Leskiw, Can-Ag Enterprises Ltd.

Highvale Soil Reconstruction Project (82-13-SCH) - L.A. Panek, Monenco Consultants Ltd.

Grain and forage yields are being evaluated on a series of soil reconstruction plots at the Battle River (Figures 3a to f) and Highvale (Figures 4a to c) mining areas. Treatments include: depth of subsoil (0 to 3 m thicknesses) over sodic spoil, use of bottom ash and gypsum as amendments to sodic spoil, and reconstruction of solonetzic soils. Salt movement over spoil slopes is also being studied. The project began in 1979 at Battle River and plot construction was completed at Highvale in 1982.

Status: Cropping and soil sampling began at Battle River in 1982 and we now have five crop years of data. A summary report is being prepared. The first crop was grown at Highvale in 1983. After an intensive five-year program, both sites will be monitored for another five years.

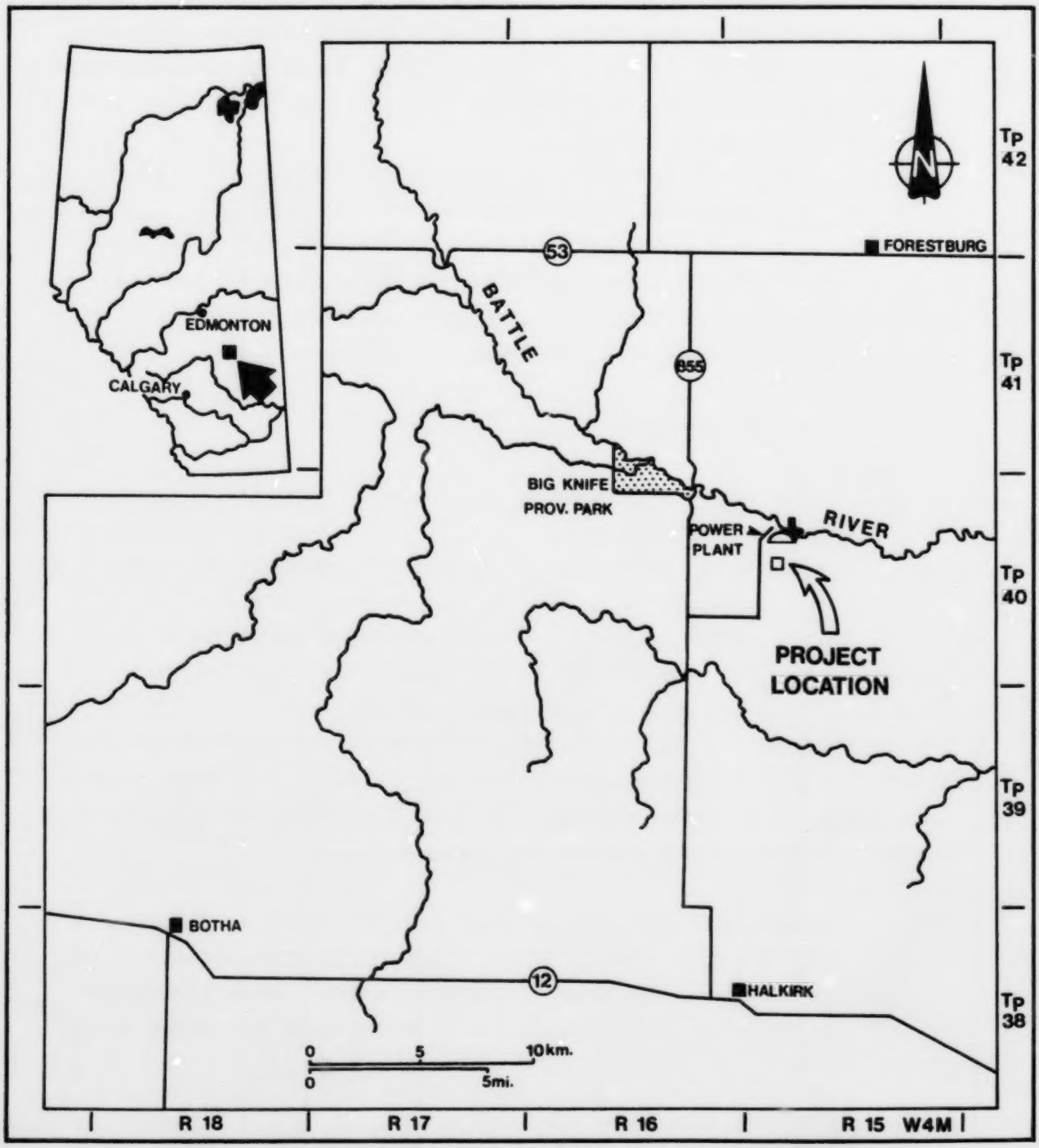


FIGURE 3a. LOCATION MAP, BATTLE RIVER SOIL RECONSTRUCTION PROJECT

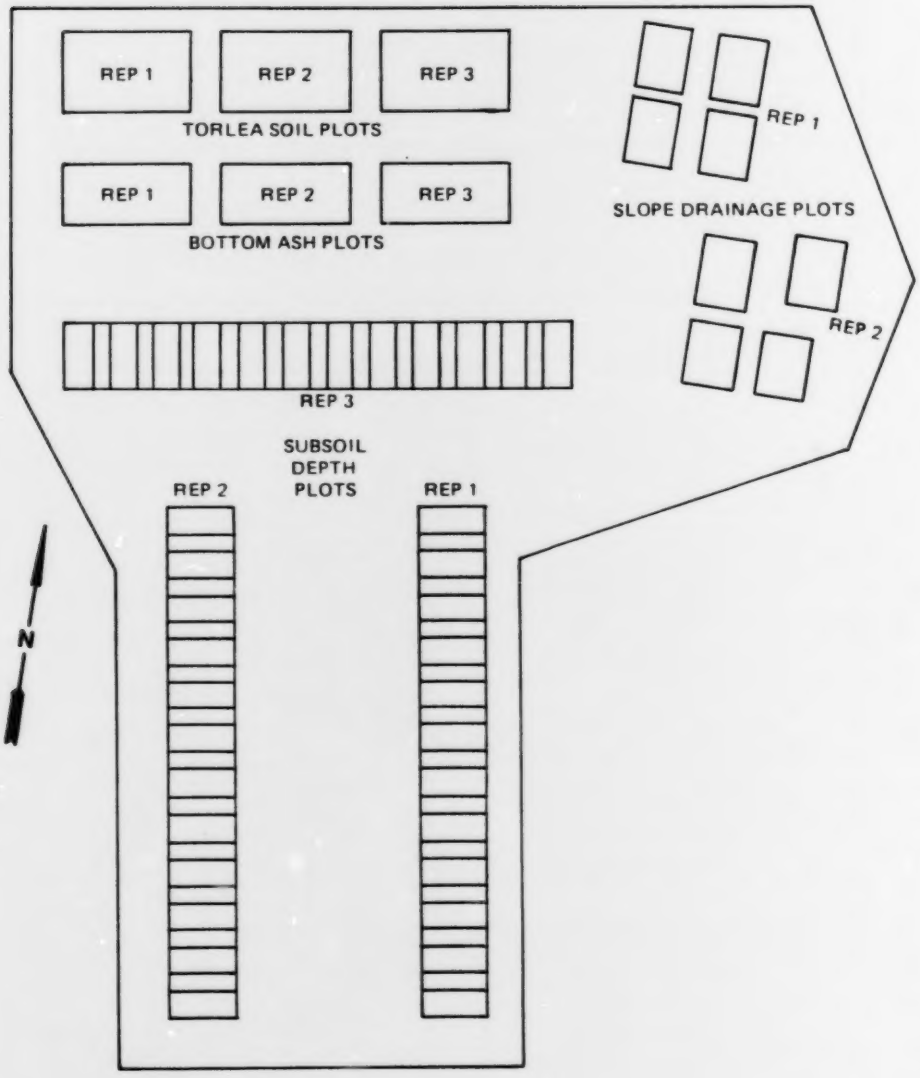
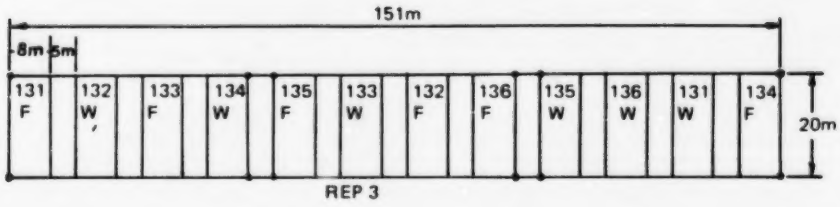


FIGURE 3b COMPOUND LAYOUT, BATTLE RIVER SOIL RECONSTRUCTION PROJECT



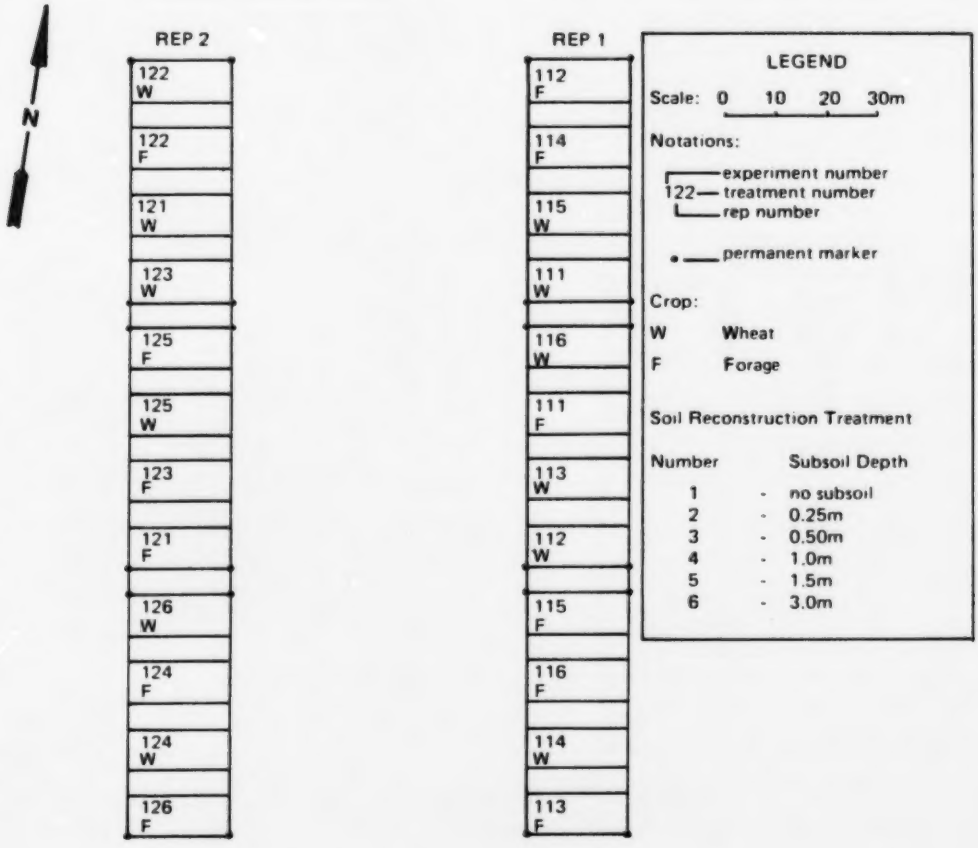


FIGURE 3c. PLOT LAYOUT – SUBSOIL DEPTH EXPERIMENT, BATTLE RIVER SOIL RECONSTRUCTION PROJECT

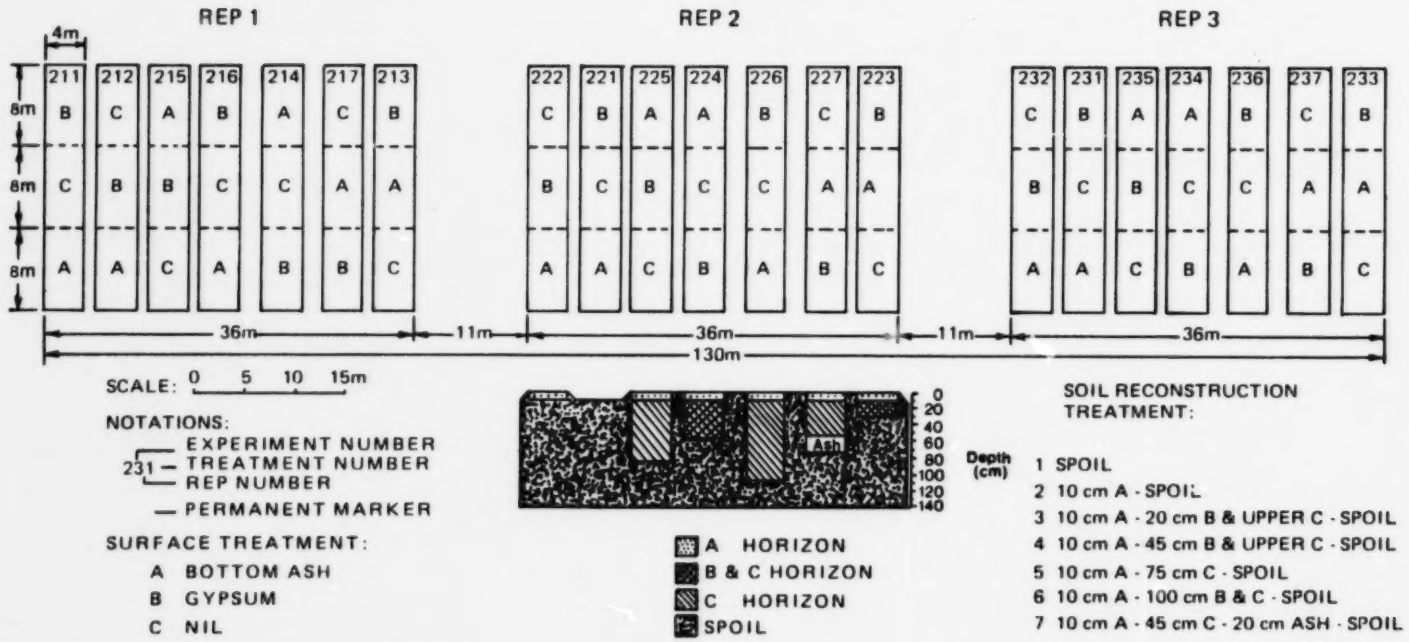
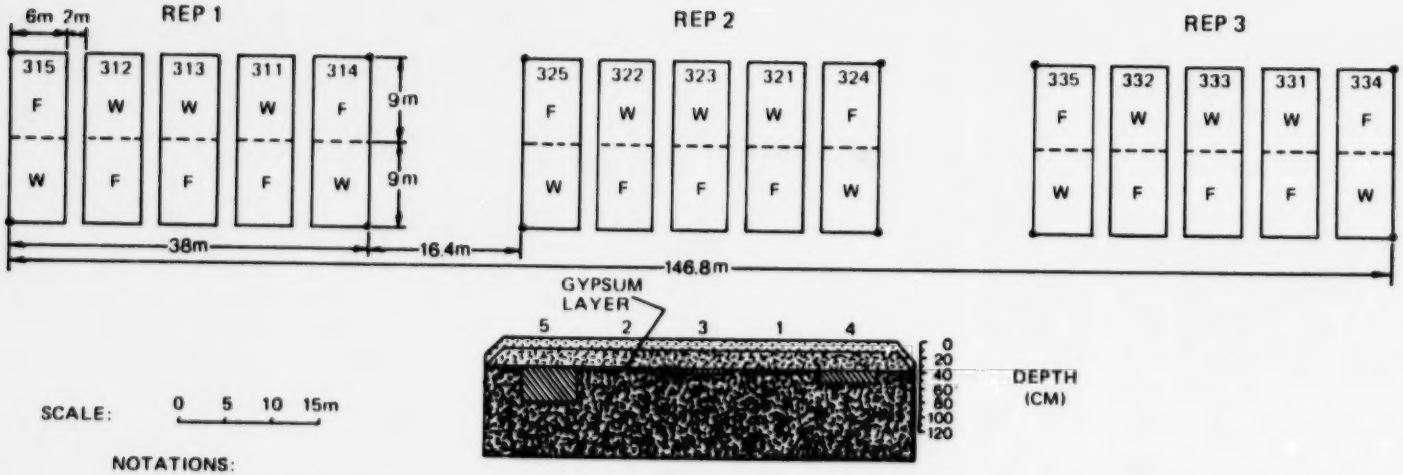


FIGURE 3d. PLOT LAYOUT – TORLEA SOIL EXPERIMENT, BATTLE RIVER SOIL RECONSTRUCTION PROJECT



NOTATIONS:

—EXPERIMENT NUMBER
324 —TREATMENT NUMBER
—REP NUMBER

•—PERMANENT MARKER

CROPS:

W - WHEAT
F - FORAGE

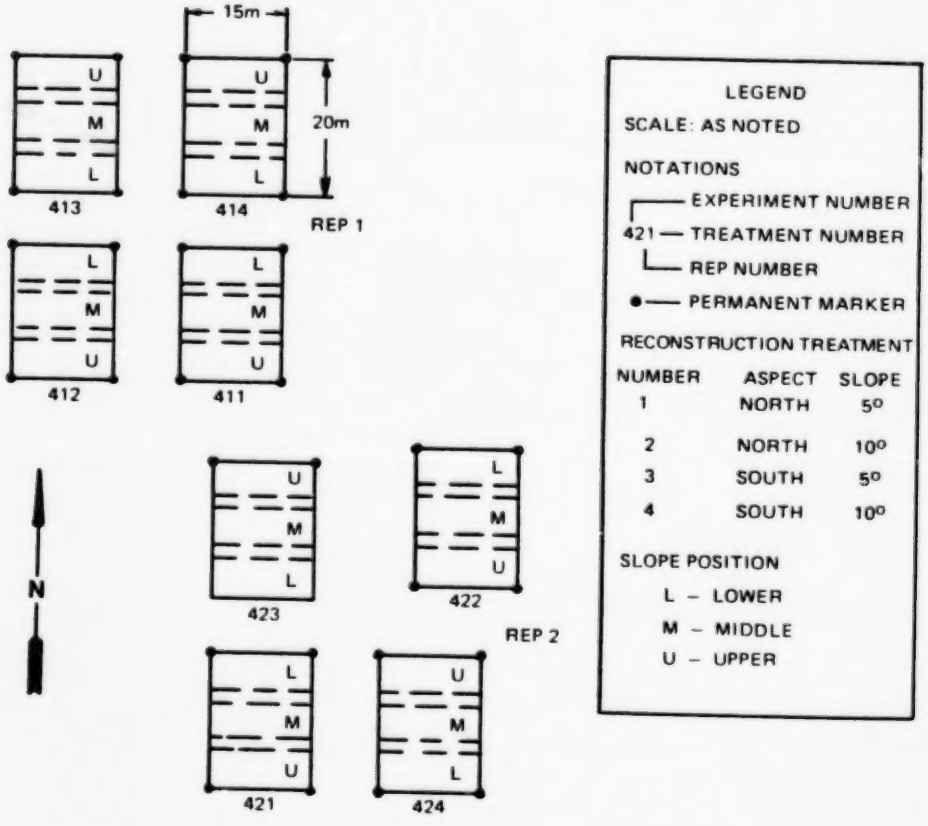
TOPSOIL
SUBSOIL
ASH
SPOLL

SOIL RECONSTRUCTION TREATMENT

1 - 15 cm TOPSOIL - 25 cm SUBSOIL - SPOLL
2 - 15 cm TOPSOIL - 25 cm SUBSOIL - GYPSUM* - SPOIL
3 - 15 cm TOPSOIL - 25 cm SUBSOIL - 5 cm ASH - SPOIL
4 - 15 cm TOPSOIL - 25 cm SUBSOIL - 15 cm ASH - SPOIL
5 - 15 cm TOPSOIL - 25 cm SUBSOIL - 45 cm ASH - SPOIL

* GYPSUM LAYER APPLIED AT 20 TONNES/HECTARE BETWEEN SUBSOIL LAYER AND SPOIL ON TREATMENT 2.

FIGURE 3e. PLOT LAYOUT – BOTTOM ASH EXPERIMENT, BATTLE RIVER SOIL RECONSTRUCTION PROJECT



CROSS SECTION

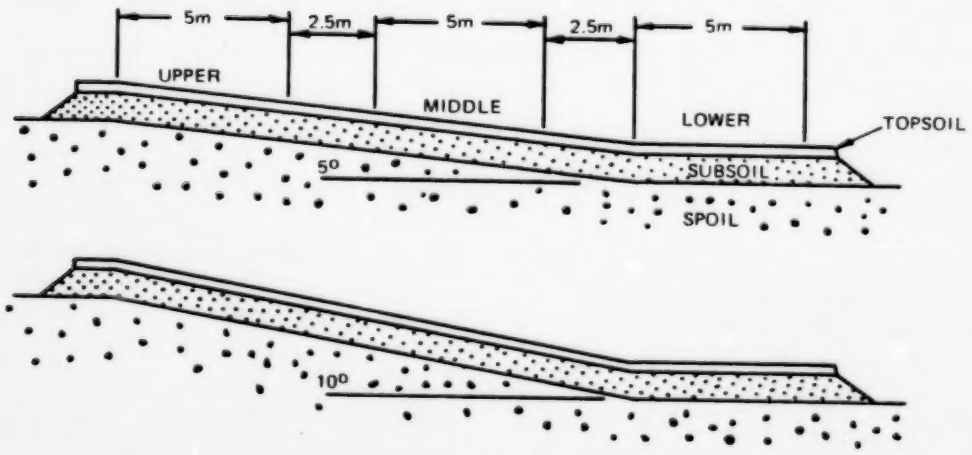
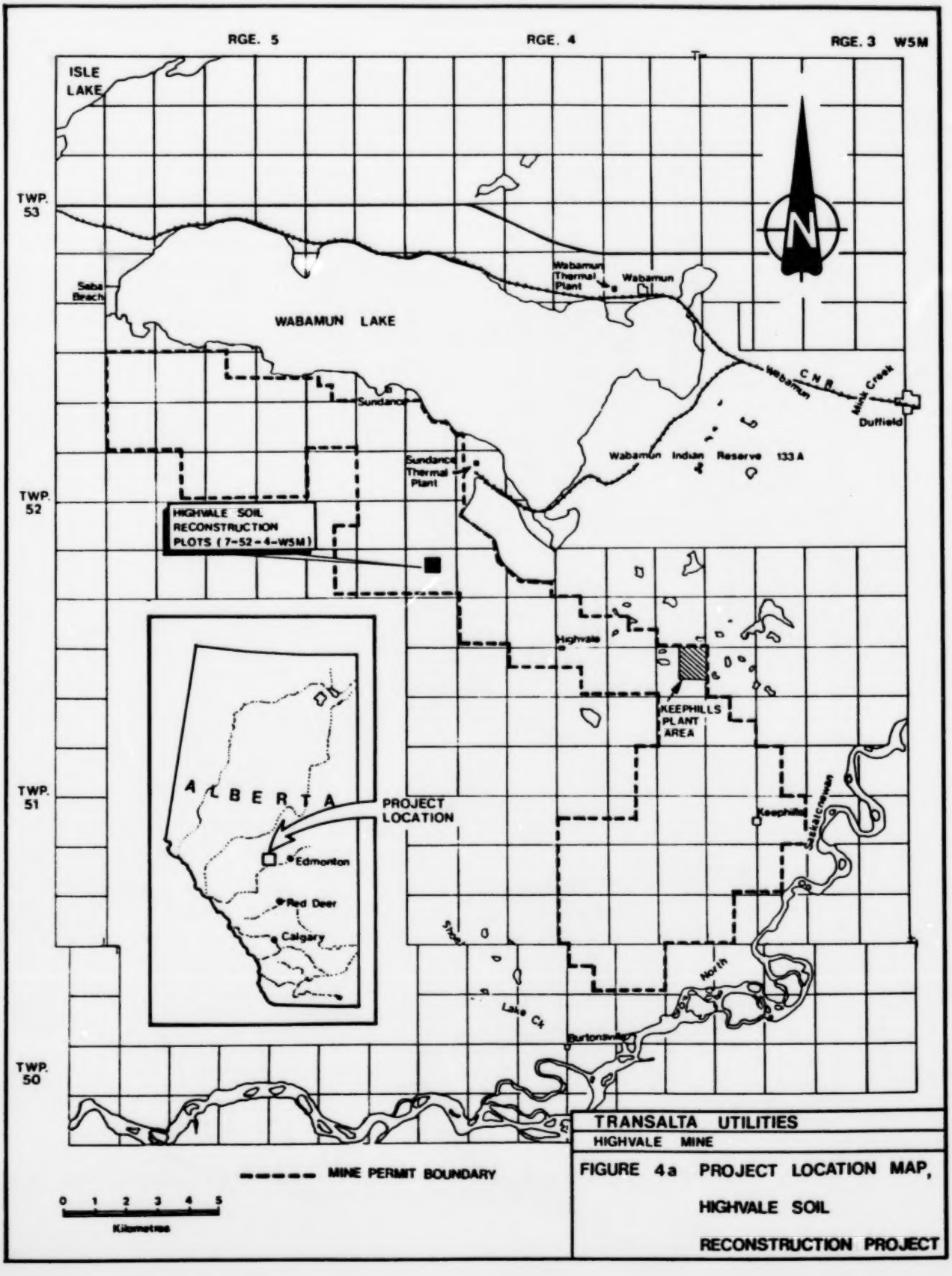


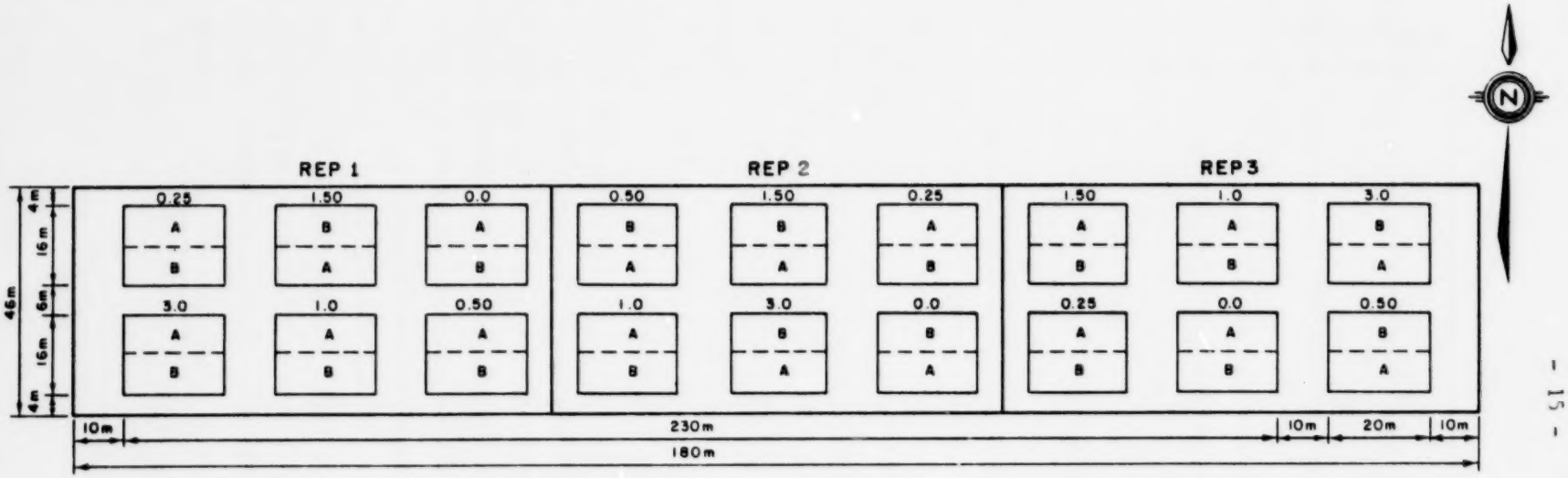
FIGURE 3f. PLOT LAYOUT – SLOPE DRAINAGE EXPERIMENT, BATTLE RIVER SOIL RECONSTRUCTION PROJECT



TRANSALTA UTILITIES

HIGHVALE MINE

FIGURE 4a PROJECT LOCATION MAP, HIGHVALE SOIL RECONSTRUCTION PROJECT



A - ALFALFA (Rambler) AND BROMEGRASS (Charlton)
B - BARLEY (Klondike)
0.0 NO SUBSOIL
0.25 0.25m SUBSOIL
0.50 0.50m SUBSOIL
1.00 1.00m SUBSOIL
1.50 1.50m SUBSOIL
3.00 3.00m SUBSOIL

FIGURE 4b.

HIGHVALE SOIL RECONSTRUCTION PROJECT

SUBSOIL EXPERIMENT
LAYOUT

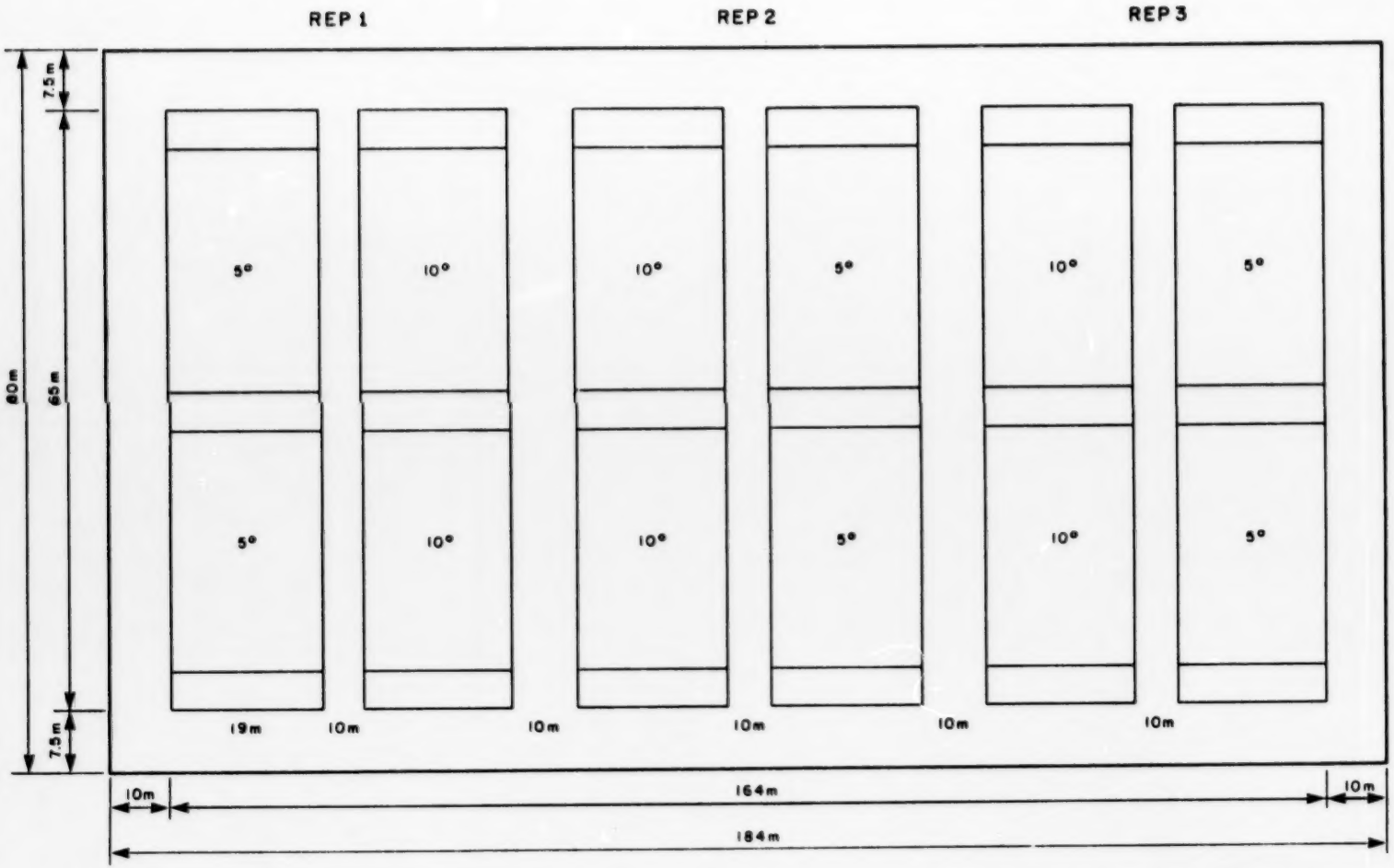


FIGURE 4c.

HIGHVALE SOIL RECONSTRUCTION PROJECT

SLOPE EXPERIMENT

LAYOUT

(NOT TO SCALE)

FORAGE CROP

2.1.5 Hydrology

Plains Hydrology and Reclamation Project (72-2-MOR) - S.R. Moran, Alberta Research Council

This study examines the impacts of surface mining on the regional groundwater, geology and soils. The main objectives include the identification of:

1. Changes in groundwater quality and quantity after mining;
2. sources and release rates of groundwater contaminants (mainly salts);
3. changes in distribution of groundwater after mining (will the groundwater carry salts to the surface, will the watertable drop or will it re-establish at pre-mining levels); and
4. surface stability after mining (subsidence, piping).

Critical groundwater and geologic parameters will be identified which should allow us to predict the "reclaimability" of a site prior to mining. This project began in 1979 and is being conducted at the Battle River and Highvale sites.

2.1.5.1 Phase 1. During 1979-1980, the first year of the five-year Phase 1, instrumentation to collect basic data on the geology, subsurface water, and soils of the Battle River mining area was installed. Mapping of the soil and geology of the area, and a program of testhole drilling were also included in the initial phase of pre-mining site characterization. In spite of a late start during the first year, most of the instrumentation that was planned was installed but no data were collected.

During the second year (1980-1981), approximately 90% of the instrumentation needed to characterize the Battle River site was completed. Monitoring programs that were begun in the very late stages of 1979-1980 were continued throughout 1980-1981. A considerable body of data on properties of overburden materials and chemistry and movement of subsurface water was accumulated by the end of 1980-81. In addition, experimental studies were

initiated to describe the total salt yielding properties of various types of overburden materials under a range of conditions of water content and oxygen access.

During 1981-82, experimental studies on physical and chemical weathering of overburden materials at the Battle River site were carried out. Various physical and chemical properties of the overburden, such as grain size and mineralogy, were determined and related to weathering characteristics. Field studies were completed to define hydrologic conditions at the Battle River site. Unanticipated complexities in flow patterns in spoil at Diplomat Mine, combined with problems with experimental techniques used to measure infiltration in spoil required further work on spoil hydrology at that site. Significant progress was made in the computer modelling of mine-affected groundwater flow systems. Study of post-mining groundwater supply potential was nearly completed and general conclusions began. Preliminary synthesis of project data into a two component predictive model was possible. Hydrologic parameters that will permit projection of post-mining watertable configuration were identified and evaluation of their interactions had advanced well. The chemical component of the model had not advanced as far but the basic elements were identified.

During 1982-83, evaluation of the Highvale site began with the installation of hydrologic monitoring instrumentation. Major efforts focussed on evaluation of hydrogeology and chemistry of mine spoil at both the Highvale and Whitewood Mines. In addition, the existing network of wells installed by TransAlta Utilities Corporation to monitor groundwater in the unmined area adjacent to the Highvale Mine was expanded. A series of sites to monitor water movement in the unsaturated zone was installed. Initial study of the weathering characteristics of overburden was begun.

At the Battle River site, new instrumentation was installed to refine our understanding of spoil hydrology and the flow of groundwater from the spoil into adjacent aquifers. Infiltration tests were successfully completed in the spoil and improved techniques of analysis greatly increased the amount of data that was derived from these and preceding tests. These data combined witn groundwater data improved our understanding of groundwater recharge in the area. Overburden weathering studies were completed and a

preliminary procedure to relate weathering data to groundwater chemistry in spoil was developed. Groundwater-flow modelling provided some significant insight into the spoil resaturation process. Following grading, preferential settlement of areas between the original spoil ridges appears to facilitate infiltration of surface water, which promotes further settlement.

The fifth year of the study (1983-84) served as a period of refinement of the predictive framework developed at the Battle River site. At the Highvale Mine site, instrumentation was completed and field scale experiments installed at both sites to test the validity of the overall predictive framework on salt yield of the overburden.

The following represents a partial list of the conclusions from the first phase of the project:

1. Soluble salts already present in abundance in the overburden are sufficient to produce groundwater in spoil that has chemical quality substantially reduced relative to premining aquifers.
2. Weathering of overburden has very limited potential to substantially increase the salt reservoir within reclaimed landscapes.
3. There appears to be no justification for additional selective handling and placement of soil and overburden material over and above that currently practiced as a means to improve chemical quality of groundwater or to decrease potential for soil salinization.
4. There was no evidence of perching of water near the land surface, either within the subsoil or at the interface between the subsoil and spoil. (This conclusion has subsequently changed as a result of continued observations during Phase II.)
5. Discharge of spoil groundwater to surface streams should not result in measurable deterioration of chemical quality of receiving streams.
6. In some settings, discharge of spoil groundwater can significantly degrade chemical quality in shallow groundwater beneath unmined terrain adjacent to reclaimed areas at least 1.5 km from the mine boundary.

7. Mining will destroy all aquifers located above the base of the mine. Except in very rare cases, replacement aquifers cannot be re-established within the mine spoil. In some areas of the Lower Horseshoe Canyon Coal Zone, alternative aquifers can be exploited beneath the base of mining.
8. Reconstructed soil landscapes are characterized by a higher degree of small-scale variability and lower degree of large-scale variability than are unmined soil landscapes.
9. The capability for agricultural production of reconstructed landscapes can be described and evaluated by a system that is essentially equivalent to that used in unmined landscapes.
10. Using the capability rating system that was developed by the project, it was determined that reconstructed soil capability was generally equivalent to the premining soil capability. Post-mining capability reflects a more "average" capability as compared to the relatively higher and lower capability ratings attached to soil units in the premining landscape.

2.1.5.2 Phase II. The second phase of the project, which has a scheduled duration of three years, began in 1984-85. The objectives of the second phase of study were reformulated from the objectives of Phase I to reflect the knowledge gaps identified in Phase I. The three subobjectives of this second phase focus on:

1. Design and construction of reclaimed landscapes that maximize long-term agricultural capability by minimizing potential salinization through the management of water in the landscape;
2. Assessing changes in agricultural capability and productivity of reclaimed landscapes on a long-term basis; and
3. Refining our understanding of groundwater chemistry and recharge in reclaimed landscapes, as well as groundwater-induced salinization effects adjacent to reclaimed areas.

Work during 1984-85 focused on installation of intensive instrumentation in a number of slope and depressional settings in reclaimed

and analogous unmined sites, primarily in the three mines at the Battle River site. Only preliminary data were accumulated from this new instrumentation.

During 1985-86 work focused on completion of instrumentation at field capillary study sites and along slope profiles in reclaimed settings, and at unmined reference slope sites. In addition, an experimental site to evaluate vertical salt migration above a shallow water table in a simulated spoil profile was constructed. A second set of false-colour infrared photography was obtained, interpreted and ground checked as part of our analysis of techniques to identify distribution of soil salinity in reclaimed sites. A tracer study using bromide ion was conducted to assess the contribution to soil salinization by lateral flow in the unsaturated zone. Instrumentation of spoil subsidence sites at Vesta and Paintearth Mines was completed. The other two major activities were monitoring of project instrumentation and continuing synthesis of results and completion of Phase I reports.

In 1986-87, data collection continued, but the major activities focused on re-synthesis of models of infiltration and groundwater recharge, salt and water movement, and surface stability in reclaimed landscapes. The following is a partial list of conclusions arising out of Phase II of the project:

1. In well-drained landscape positions in reclaimed terrain, sodium is moving downward, suggesting that the quality of reconstructed soils in these settings is improving over time.
2. In well-drained landscape positions in reclaimed terrain, bulk density is decreasing with time. It appears that a significant portion of the decrease in density occurs in the initial five to seven years following reconstruction.
3. Saline conditions develop where the water table is within about 1.0 to 1.2 m of the surface in the loamy, till-derived subsoil material that is typical of the Battle River mining area. In unmined settings in the same area, saline conditions have been observed where the water table is as much as 2.0 m below the surface.

4. Strong upward capillary transport of water and salt is limited to a zone about 0.6 m above the water table in the loamy, till-derived subsoil material that is typical of the Battle River mining area.
5. Depressions formed by differential subsidence in reclaimed landscapes contain ephemeral ponds that are potentially significant contributors to groundwater recharge during spring melt and heavy precipitation events.
6. Steady-state groundwater conditions are established in most sites in reclaimed landscapes within 10 to 15 years following mining where deep surface ponds are present and the spoil is 10 to 20 m thick.

Status: Phase II marks the completion of this major undertaking. The Alberta Research Council has recommended further work. Approximately 25 research reports are expected to be generated from this research project, including a summary report in the next two years. Several reports have already been released: RRTAC 86-2, 86-3, 86-4, 86-5, 86-6, and 86-7.

2.1.6 Soil Water Interactions

Water Balance in Sodic Spoil (85-8-JOH) - R. Johnson, Alberta Environmental Centre

Work conducted by the Alberta Research Council has shown that depth of the water table in a saline sodic soil system can have a great effect on the quality of the rooting zone soil.

This study was initiated in 1986 to determine the effects of crop type, depth to groundwater and microclimate on salinity and water movement in reclaimed soils. Large lysimeters (75 cm wide x 100 cm deep) have been developed at the Alberta Environmental Centre and will be planted to annual grain (barley or wheat), forage (alfalfa) or left fallow. One half of the lysimeters will have a watertable maintained at 95 cm, the others will be free draining.

The data collected will allow development of a model that can predict soil moisture content and movement over large areas with few data inputs. This will allow land managers to predict optimum locations for crops on a reclaimed landscape and to predict the effects of those crops on soil water balance.

Status: The project is ongoing.

2.1.7 Ash Amendments

Use of Bottom Ash as an Amendment to Sodic Spoil (83-4-LAN) - S. Landsburg, Alberta Environment

Prior to the current practice of soil salvage and replacement, surface mined land in the Plains generally reverted to waste land. This was particularly true where sodic overburden was encountered. Reclamation of these orphaned areas in the absence of suitable soil requires amendment of the sodic spoil surface. Perhaps the most promising amendment appears to be bottom ash from the nearby power plants. Earlier research indicated that this waste product possesses the ability to significantly improve sodic spoil. This project will identify, through field testing, which ash amendment rates and incorporation methods are most effective in developing at least minimal productive potential in orphaned sodic spoil.

Status: The research is completed and a final report is under review.

2.2 MOUNTAINS AND FOOTHILLS RECLAMATION RESEARCH PROGRAM

In 1984, The Coal Association of Canada and RRTAC initiated the jointly-funded Mountains and Foothills Reclamation Research Program (MFRRP). The program's focus is on Water Management, Soil Reconstruction, Reforestation and Wildlife Habitat Development.

2.2.1 Reclamation Objectives

1. Control of erosion on a variety of disturbances including coal mines, mineral exploration sites, coal ash pits and oil and gas sites.
2. Return of forested lands to previous levels of capability.
3. Return of wildlife range to previous levels of capability.

2.2.2 The Problem

Reclamationists in the mountains and foothills face a wide variety of conditions. While some foothill sites are characterized by subdued terrain and moderate climate, other sites, particularly in the mountains, present steep slopes, rocky spoil and a short growing season. On these problem sites, summer droughts, chinook winds, erodible slopes and nutrient-poor soils are common.

On lower elevation foothill sites, reclamation is expected to yield forests with commercial potential while on the higher elevation mountain sites erosion control, development of wildlife habitat and recreation potential are the reclamation objectives.

Reclaimed land in the mountains and foothills will not be as intensively managed as reclaimed agricultural lands would be. Also, topsoils and subsoil layers tend to be thin and difficult to handle selectively. Nonetheless, they are a valuable source of plant nutrients. So while some mixing of horizons is inevitable, how much is acceptable? How thick should the replaced soil layer be? Other sites simply have no salvageable topsoil and reclamation must prepare the site so that a plant-soil system will develop which will perform its land use expectations without indefinite fertilization.

2.2.3 Research Approach

There are four important aspects to reclamation in the Mountains and Foothills region:

1. The creation of stable reclaimable landscapes. This includes dump design (optimal slope, angles and lengths, terracing) and pit backfilling.

2. Preservation of watershed integrity and water quality. Water flow and sediment control are of prime interest.
3. Reconstruction of a suitable growing medium for each land use. The goal is to make the best use of limited materials to improve the root zone over rocky, nutrient poor spoil.
4. Selection of suitable vegetation for each land use and proper planting to ensure survival and growth. The goal is creation of a self-sustaining cover that does not require long-term maintenance.

2.2.4 Landscape Design

Mountain and Foothill Dump Design (82-14-CHO) - R.G. Chopiuk, Coal Mining Research Company

In Phase I, resloped overburden dumps in Alberta and British Columbia were surveyed to identify practical construction and resloping strategies. It was found that many, though not all dumps, were graded to shallower slopes (22 to 24%) than had been designed (27%). Operator and machine limitations were cited.

In Phase II, a number of slopes were instrumented to identify the volumes of erosional loss due to various slope angles, lengths, berms and topsoiling. After two years of monitoring, the conclusion was that there is little concern about waste dump erosion. Where erosion did occur on slopes (primarily in the first year after reclamation), there was a tendency for the materials to be quickly deposited on lower portions of the slope. There was no evidence of eroded material leaving the waste dump area.

Status: The project is completed and a final report is in press.

2.2.5 Watershed Design

Analysis of Settling Pond Design and Alternative Technologies (84-12-MON) - A.H. Somani, Monenco Consultants Ltd.

Methods for design and construction of settling ponds were evaluated with respect to Mountain and Foothill conditions. Also, alternatives to settling ponds were assessed.

Status: The project is completed and details released as Report #RRTAC 86-1.

Settling Pond Research - Phase II (86-10-BEA) - B. Bietz, Beak Associates Consulting Ltd.

The purpose of this project is to establish the scientific basis for the existing water quality and quantity legislation for mines in the Eastern Slopes of Alberta and to document the source and basis for various parameters for water quality and design flows with specific reference to the Alberta East Slopes conditions.

Status: Project is completed and a final report is in press.

Assessing Design Flows and Sediment Discharge on the Eastern Slopes (86-11-HYD) - G. Beckstead, Hydrocon Engineering Ltd.

In this study, the literature will be evaluated and a methodology selected to assess precipitation, flood flows, and sediment discharge in mountain/foothills regions of Alberta with respect to their implications for settling impoundment design, and culvert and drainage ditch sizing in coal mining developments. Also included is the design a field program to measure the most critical parameters for erosion and sediment of control structures.

Status: Phase I is complete. The final report is in press. Planning for Phase II which involves data collection at selected mine sites is underway.

2.2.6 Soil Reconstruction

Soil Reconstruction in Mountain and Foothill Coal Mining (84-23-PED) - L. Knapik, Pedocan Land Evaluation Ltd.

This review assembled available information to facilitate operational reclamation decisions to provide for tree growth (forestry use), shrub growth (wildlife habitat) and herbaceous cover (erosion control). This review also identified information gaps and recommended needed research.

Status: Project is finished and a final report is in press.

2.2.7 Revegetation

Selection of Native Grasses for Reclamation (79-7-WEI) - R. Hermesh, Alberta Environmental Centre (AEC).

Many alpine and subalpine sites are difficult to reclaim simply because commercially available grasses and legumes either cannot survive or cannot reproduce in the short growing season. This study is selecting lines of native grasses which are known to invade disturbances in subalpine and alpine areas. Selections are made on the basis of commercial potential and fitness for reclamation.

Status: The project is ongoing. More information is available in AEC annual reports.

Growth Performance of Commercial Timber Species in Reclamation (84-28-DEM) - W.R. Dempster and Associates Ltd.

The purpose of Phase I of this study was to review and report, from available literature, growth performance data that could be used to develop standards expected of commercial timber species for reclaimed lands in the Eastern Slopes of Alberta. Phase II involved selection of a suitable growth performance, measure and field data collection in the Eastern Slopes.

Study parameters included:

1. Rates of juvenile growth, and appropriate measurement techniques and timing, required to provide reasonable assurance of successful reclamation;
2. The impact of site and cultural factors on growth performance, and the extent to which growth can be predicted from these factors;
3. Recommendations for the development of growth performance standards or guidelines including growth rate expectations, assessment methodology, the length of time required to assess performance, and the extent and acceptability of management inputs; and
4. Further research required to assist in the formation of growth standards and guidelines.

Status: The project is completed and the final report is under review.

Reclamation for Wildlife Habitat in the Mountains and Foothills of Alberta: Phase I: Literature Review, and Phase II: Wildlife Habitat Certification Handbook (84-18-LGL) - J.E. Green, LGL Ltd.

Phase I of this study addressed: the synthesis of current information on habitat requirements of major wildlife species in the Mountains and Foothills of Alberta; an evaluation and collation of information on reclamation procedures for wildlife habitat; the applicability of these methods to Alberta; and, the development of criteria for the assessment of wildlife habitat reclamation procedures for certification purposes.

Phase II involved further evaluation of the literature on habitat assessment procedures. The information was used to develop models that could be used by field officers and mine planners to evaluate success of reclamation for a given habitat and key wildlife species.

Status: The project is completed. A report from the Phase I study is in press. The Phase II report is under review.

2.3 OIL SANDS RECLAMATION RESEARCH PROGRAM

In order to pool resources and avoid duplication of effort, RRTAC and industry initiated a joint research program in 1979. Priority research areas included woody plants (propagation, establishment and management) and soil reconstruction. In 1986, the program was expanded to include reclamation of tailings pond sludges.

Syncrude Canada Ltd. has been a very active supporter of this program providing research facilities and funds.

2.3.1 Reclamation Objectives

1. To develop techniques whereby a self-sustaining, erosion-free cover can be established on oil sand tailings pond dykes; and
2. To return tailings sand storage and overburden dumps to productive forest.

2.3.2 The Problem

Northeast Alberta contains all of Canada's surface-mineable oil sands. Extraction of this valuable petroleum resource presents several problems for reclamation. By far, the greatest problem lies with the tailings disposal systems currently employed.

At the end of its 25-year life, a typical oil sand plant producing 19 900 cubic meters per day (125 000 barrels per day) of synthetic crude oil will require a 22 to 31 square kilometer (8.5 to 12 square mile) tailings pond. The liquid contents of the pond will consist primarily of 360 million cubic meters of sludge. The sludge will remain in a liquid state indefinitely and will be impounded behind dykes built of tailings sand. Dyke heights will research from 55 to 100 meters above ground level. Erosion protection will be provided by a cover of grasses, legumes and shrubs. Because the tailings sand is devoid of nutrients and drains rapidly, amending materials (muskeg, certain mineral overburdens) will be added to begin development of a soil.

Pits left after mining will be filled with tailings sand and overburden dumps will be constructed. These sites will also be reclaimed to a designated land use. Soil reconstruction and woody plant establishment in particular need further research.

2.3.3 Research Approach

As in the mountains and foothills, proper reclamation in Northeast Alberta will produce landform and plant community combinations which will fulfill their land use requirements without indefinite maintenance.

The approach to revegetation is to identify the best woody species to plant in reclamation areas and to identify the best soil amendments for tailings sand. Biological (plant species) and physical (slope, sand/sludge mixtures, freeze/thaw cycles) methods for dewatering tailings pond sludge are also being investigated. By dewatering sludge, a material with considerably less volume and with better engineering (trafficability) properties is created.

2.3.4 Revegetation

Oil Sands Soil Reconstruction Project (83-10-HAR) - H.E. Martens, Hardy Associates (1978) Ltd.

Field trials were established on a 7 ha pad of tailings sand prepared by Syncrude Canada Ltd. on their property north of Fort McMurray. Various mixtures of peat and clay were incorporated to 20 and 40 cm depths. In 1984, the plots were planted with tree and shrub species to identify the best soil prescription for a particular forest cover type. Data are being collected each year on tree/shrub survival, growth and spread and on soil moisture and soil nutrients.

Status: The project is ongoing.

Mycorrhizal Potential in Reconstructed Soils (81-2-PAR) - B. Danielson, University of Calgary.

Mycorrhizal fungi nearly always enhance tree nutrition. This project has determined the survival and inoculum potential of mycorrhizal fungi in undisturbed and stockpiled peat to be used in oil sand tailing reclamation. Also, fungal species have been selected for use in jack pine seedling inoculation. Their effect on tree growth is being monitored in field trials.

Status: The project is completed and a final report is in preparation. See Report #RRTAC 84-4 for results of earlier studies.

Biological Dewatering of Oil Sand Tailings (86-9-ALL), D. Allen, Alberta Environmental Centre.

Work at AEC in 1985 demonstrated the ability of various plant species to dewater oil sand tailings sludge in 45-gallon drums to a point where the material was essentially solid. In 1986, RRTAC joined AEC and Syncrude Canada Ltd. in a small scale field test of this technology. Pits were constructed and filled with a mixture of tailing sludge, sand and lime and plants were introduced. Due to unforeseen problems, such as pit flooding caused by a nearby dredge, the vegetation was unable to establish. However, valuable information on the physical behaviour of the sludge in larger tanks was obtained.

Status: Work is ongoing. More details are available in AEC annual reports.

2.4 OIL AND GAS RECLAMATION RESEARCH PROGRAM

Conventional oil and gas deposits are found in all three biophysical regions noted above, while heavy oil deposits are found in the northeast. Since these disturbance types create similar reclamation concerns (disposal of sump fluids, compaction) regardless of biophysical region, a separate program was developed to co-ordinate research.

2.4.1 Reclamation Objectives

1. To develop environmentally-safe methods for disposal of drilling wastes (fluids and solids)
2. To return land to a condition capable of sustaining an approved land use.

2.4.2 The Problem

2.4.2.1 Drilling wastes. Three basic drilling muds and variations thereof are used for oil and gas exploration in Alberta. The freshwater gel bentonite

is most commonly used followed by the salt water systems which use sodium or potassium. The oil invert drilling mud is little used but is gaining in popularity. Diammonium phosphate (DAP) mud is being used in the Cold Lake region.

The wastes produced from drilling operations contain many complex organic and inorganic compounds that are added at various stages of the drilling process. The materials that start out as drilling mud are usually extensively altered chemically and physically by the time they enter a waste pit. The muds can be altered by heat and pressure effects associated with drilling and by the addition of drill cuttings brought up with the mud system. The materials found in the waste pit can also be changed chemically and physically by other products that are purposely or inadvertently added to the pit. Caustic soda rig wash, diesel fuel, waste oil from machinery, metal and plastic containers and other refuse often find their way into a waste pit.

Drilling wastes are currently disposed of by burying, trenching, squeezing, and spreading. Each of these disposal methods impacts the environment in different ways. For example, interactions of waste constituents with groundwater is much more likely to occur if wastes are trenched or buried as opposed to surface spread. The reverse is true for soils and plants.

Review of the literature indicates that effects of disposal of drilling wastes on plants and soils varies with the type of waste, rate of application and plant species.

A thorough physical and chemical analysis of the liquid and solid phases of wastes generated by drilling operations utilizing the different mud types is one of the prerequisites to assessing potential environmental hazard of the disposal of these wastes and developing environmentally-safe disposal methods.

2.4.2.2 Compaction. A survey conducted by the Pipeline and Wellsite subcommittee of RRTAC found that Reclamation Officers perceived soil compaction to be the prime concern in reclaiming oil and gas wellsites. Repeated passage of heavy equipment during development and operating phases of a wellsite result in compaction of the soil. In some cases, seedbed

preparation using conventional equipment does not appear to completely alleviate compaction. This results in poor growth of plants.

2.4.3 Research Approach

In 1984, RRTAC sponsored a two-day workshop on drilling waste disposal in Alberta (in press). The workshop identified a number of concerns that needed to be addressed.

As a result of this workshop, initial research focussed on trying to develop a manual that could be used by field staff to determine whether a waste could be safely spread on a given soil surface. The manual pointed to a need for detailed chemical characterization of sump fluids and solids before rational disposal decisions could be made. Thus, Phase I of the program has concentrated on getting chemical data from various drilling mud types in various regions of the province.

The approach to the compaction problem was to determine what characteristics predispose a soil to compaction. This knowledge will allow operators to avoid compaction wherever possible.

2.4.4 Drilling Wastes

Disposal of Drilling Muds on the Public and Private Lands of Alberta (85-9-LLO) - L. Leskiw, Pedology Consultants

This literature review evaluated options for drilling fluid disposal and indicated associated effects on soils and vegetation. Most primary disposal methods were identified and a field manual of disposal methods was developed. Areas regarding further research were identified. A technical review of existing guidelines was also conducted.

Status: Project is completed and a final report is in press.

Drilling Mud Disposal (86-12-MAC) - T. Macyk, Alberta Research Council

The purpose of this project is to provide a scientific basis for development of guidelines for drilling mud solids disposal that optimizes

environmental safety and cost effectiveness by carrying out problem analysis, and preliminary research to identify environmental limitations of available disposal technology. Drilling waste fluids and solids were collected from sumps at wellsites in Cold Lake using KCl, NaCl and freshwater muds. Samples were collected at several depths and in several locations within a sump to determine spatial variability in chemistry. A suite of chemical analyses were performed to characterize both solids and fluids. Samples of sump solids were mixed at various rates with a soil indigenous to the region and planted to a grass species typically used in reclamation.

Status: Project is ongoing. Samples from Eastern Slopes wellsites will be collected in 1987 and the information for the two regions collated into a final report.

2.4.5 Compaction

Soil Compaction (86-13-JOH) - J. Campbell, Alberta Environmental Centre.

This project has three objectives:

1. To identify a measure of soil compaction useful for field evaluations on reclaimed oil and gas leases in Alberta;
2. To develop "trafficability" guidelines to prevent soil compaction on oil and gas leases in Alberta; and
3. To identify the most effective and cost-efficient method of permanently alleviating soil compaction on oil and gas leases in Alberta.

The research was conducted in the laboratory using soils typical of wellsites in Alberta. Several new techniques and pieces of equipment were developed to measure soil compaction and soil physical properties in the lab.

Status: Project is finished. A final report is in preparation. The knowledge gained in this study is being used in a 1987 field survey of compaction.

3.1 Previous Research.

PROBLEM AREA	RESEARCH PRIORITIES	DESCRIPTION
Program: Plains Coal Reclamation Research Program		
Objective: Restoration of Agricultural Research Program		
Groundwater/ Geology	- Effects of mining on groundwater supplies - Generation of salts in spoil - Transport of salts near the reclaimed soil surface - Subsidence after reclamation - Effects of underground ash disposal - Overburden classification	The regions including and surrounding the Battle River and Highvale Mining areas are being intensively monitored to assess the effects of mining on the soil, water and ultimately, the agricultural resources. As significant concerns are identified remedial measures are also evaluated. Phases I and II of the hydrology project are completed. The long-term effects of subsidence, salinization and soil quality are being monitored. See RRTAC Reports 80-3, 86-2, 86-3, 86-4, 86-5, 86-6, 86-7
Soil Reconstruction	- Thickness of subsoil required above sodic spoil - Effects of slope on lateral salt transport - Reconstruction of Solonetzic soils - Use of bottom ash as soil amendment - Effects of crop type - Changes in topsoil during stockpiling	Experimental plots have been constructed on the Battle River and Highvale Mine areas and 1986 will be their fifth and fourth crop years, respectively. The plots will be intensively monitored annually for at least five crop years each. An experiment to test optimum amounts of bottom ash and incorporation methods has been completed
Fly and Bottom Ash Disposal	- Chemical and physical properties of Alberta fly and bottom ashes - Potential for use as soil amendment	Ashes from five Alberta sources were analyzed for both toxicity and soil amendment possibilities. This work is completed and the results are published in RRTAC Report 81-3.

PROBLEM AREA	RESEARCH PRIORITIES	DESCRIPTION
Program: Mountains and Foothills Reclamation Research Program		
Objective: Restoration of Forestry, Wildlife and Watershed Capabilities		
Landscape Design	Design and construction of stable spoil dumps	A survey was conducted of existing reclaimed dumps in Alberta and British Columbia to identify practical resloping strategies
	Water management	A literature review identified settling pond size requirements. See RRTAC Report 86-1.
Soil Reconstruction	For various land uses	A literature review and evaluation of soil reconstruction requirements was completed
	For erosion control on ash dumps	Thickness of soil required over coal ash to support vegetation was investigated
Revegetation	Species selection	Development, assessment and field testing of native grasses for reclamation is ongoing.
	Propagation	Methods for propagation of reclamation shrubs were assesed
	Establishment	Methods for establishment of tree seedlings in grass cover were evaluated
	Fertilization, nutrients	Studies identified treatments importantto development of self-sustaining plant cover
	Erosion control	Mulches, binders and contouring techniques for erosion control on coal spoil were evaluated
	Wildlife Habitat	A literature review of methods for wildlife habitat reclamation was completed See RRTAC Report 86-9.

PROBLEM AREA	RESEARCH PRIORITIES	DESCRIPTION
Program: Oil Sands Reclamation Research Program		
Objective: Restoration of Forestry, Wildlife Capabilities and Erosion Control		
Soil Reconstruction on Tailings	Identify recipes for reconstructed soils suitable for: - Commercial forest - Non-commercial forest - Erosion control - Wildlife habitat	Identification of the chemical and microbiological properties of peat, development of mycorrhizal innoculants for jack pine and other woody species, identification of amendment level requirements. The earlier studies are largely complete and were fundamental in designing the oil sand soil reconstruction plots which were constructed in 1983. See RRTAC Reports 83-1 and 84-4.
Revegetation	- Selection - Propagation - Establishment - Management - Sampling	These projects consist of tree and shrub selection, seed collection, development of propagation techniques, and sampling methods for use on the soil reconstruction plots. See RRTAC Reports 83-5 and 84-2.
Program: Oil & Gas Reclamation Research Program		
Objective: To develop safe methods of waste disposal and return land to a condition capable of sustaining the final land use.		
Materials Handling	Identify the best methods for handling soil materials in pipeline construction in agricultural land	A survey was made of pipelines of various ages on all of our major agricultural soil types. Material handling methods were assessed and problem areas identified. Results are published in RRTAC Report 83-3.
Drilling Muds	Disposal of drilling muds	A literature review of disposal methods for KCl drilling muds was undertaken.

Program: General*

Reclamation Bibliography and Review	Document the findings of reclamation research activities and assess implications for Alberta operations	Worldwide reclamation literature has been reviewed and condensed for presentation in a report which lists and discusses existing information as pertinent to reclamation in Alberta. The data base is accessable through the University of Alberta computing system. See RRTAC Reports 82-1 and 84-1.
Workshops	Conduct workshops to determine research needs in Alberta and to disseminate research findings	See RRTAC Reports 80-4 (Forest Soils), 81-3 (Coal Ash), 83-4 (Eastern Slopes Hydrology), and 85-1 (Revegetation in Mountains/Foothills)
Reference	Provide sources of information for reclamationists	See RRTAC reports 80-5 (Plant Species Manual), 81-2 (Survey of Activities), and 82-2 (Bibliography of Soils, Geology, Hydrology and Groundwater).

* Projects with province-wide application.

3.2 1986/87 RECLAMATION RESEARCH BUDGET

Project No.	Project	1986/87 Budget ($)
PLAINS COAL RECLAMATION RESEARCH PROGRAM		
79-2-MOR	Alberta Research Council Plains Hydrology and Reclamation Project	$ 666 000.00[1]
82-5-LES	CanAg Enterprises Ltd. Battle River Soil Reconstruction Project	145 000.00
82-13-SCH	Monenco Consultants Ltd. Highvale Soil Reconstruction Project	140 000.00
MOUNTAINS AND FOOTHILLS RECLAMATION RESEARCH PROGRAM		
84-18-LGL	Delta Environmental Management Consultants Ltd. Wildlife Certification Handbook	10 500.00[3]
84-28-DEM	W.R. Dempster & Associates Ltd. Growth Performances of Commercial Tree Species	23 685.00[4]
86-10-BEA	Beak Associates Consulting Ltd. Settling Pond Research, Phase II	6 000.00[6]
86-11-HYD	Hydrocon Engineering Ltd. Assessing Design Flows and Sediment Discharge	7 000.00[7]

Co-funding Agencies

1 Alberta Research Council ($131 583)
2 Syncrude Canada Ltd. ($21 000), Suncor Inc. ($21 000)
3 The Coal Association of Canada ($10 500)
4 The Coal Association of Canada ($23 685)
5 Alberta Environmental Centre ($22 600), Syncrude Canada Ltd. ($53 800)
6 The Coal Association of Canada ($6000)
7 The Coal Association of Canada ($7000)
8 Alberta Research Council ($26 945)
9 Alberta Environmental Centre ($15 000)

RRTAC funds are provided by the Alberta Heritage Savings Trust Fund.

1986/87 RECLAMATION RESEARCH BUDGET. CONCLUDED.

Project No.	Project	1986/87 Budget ($)
OIL SANDS RECLAMATION RESEARCH PROGRAM		
81-2-PAR	University of Calgary Mycorrhizal Potential in Reconstructed Soils	33 000.00
83-10-HAR	Hardy BBT Limited Oil Sand Soil Reconstruction Project	42 000.00[2]
86-9-ALL	Alberta Environmental Centre Biological Dewatering of Sludge	33 100.00[5]
OIL & GAS RECLAMATION RESEARCH PROGRAM		
	Drilling Mud Disposal	49 715.00[8]
86-13-JOH	Alberta Environmental Centre Soil Compaction	30 000.00[9]
	TOTAL RRTAC	$1 186 000.00
	TOTAL CO-FUNDING AGENCIES	326 113.00.
	GRAND TOTAL	$1 512 113.00

3.3 LAND CONSERVATION AND RECLAMATION COUNCIL

Mr. J.M. King	Alberta Environment, Chairman
Mr. D. Fregren	Alberta Forestry, Lands and Wildlife Alberta Forest Service Deputy Chairman
Mr. M.G. Turnbull	Alberta Forestry, Lands and Wildlife Public Lands Division Deputy Chairman

3.4 RECLAMATION RESEARCH TECHNICAL ADVISORY COMMITTEE (RRTAC)

Dr. P.F. Ziemkiewicz, Chairman

Ms. S. Guenette, Secretary

Alberta Agriculture	Alberta Forestry, Lands and Wildlife	Alberta Environment	Alberta Research Council
Mr. L.C. Marciak Research and Development	Mr. T.J. Drew Alberta Forest Service	Mr. R.S. Johnson Alberta Environmental Centre	Dr. S.R. Moran Terrain Sciences
	Mr. D.G. Lloyd Public Lands	Dr. G.A. Singleton Research Management Division	
	Mr. H. Wollis Fish and Wildlife		

3.5 RECLAMATION RESEARCH REPORTS

** 1. RRTAC 80-3: The Role of Organic Compounds in Salinization of Plains Coal Mining Sites. N.S.C. Cameron et al. 46 pp.

DESCRIPTION: This is a literature review of the chemistry of sodic mine spoil and the changes expected to occur in groundwater.

** 2. RRTAC 80-4: Proceedings: Workshop on Reconstruction of Forest Soils in Reclamation. P.F. Ziemkiewicz, S.K. Takyi and H.F. Regier. 160 pp.

DESCRIPTION: Experts in the field of forestry and forest soils report on research relevant to forest soil reconstruction and discuss the most effective means of restoring forestry capability of mined lands.

** 3. RRTAC 80-5: Manual of Plant Species Suitability for Reclamation in Alberta. 2 vols. L.E. Watson, R.W. Parker and P.F. Polster. 541 pp.

DESCRIPTION: Forty-three grass, fourteen forb, and thirty-four shrub and tree species are assessed in terms of their fitness for use in Reclamation. Range maps, growth habit, propagation, tolerance and availability information are provided.

NA 4. RRTAC 81-2: 1980 Survey of Reclamation Activities in Alberta. D.G. Walker and R.L. Rothwell. 76 pp.

DESCRIPTION: This survey is an update of the original report conducted in 1976 on reclamation activities in Alberta, and includes research and operational reclamation, locations, personnel, etc.

NA 5. RRTAC 81-3: Proceedings: Workshop on Coal Ash and Reclamation. P.F. Ziemkiewicz, R. Stien, R. Leitch and G. Lutwick. 253 pp.

DESCRIPTION: Presents nine technical papers on the chemical, physical and engineering properties of Alberta fly and bottom ashes, revegetation of ash disposal sites and use of ash as a soil amendment. Workshop discussions and summaries are also included.

NA 6. RRTAC 82-1: Land Surface Reclamation: An International Bibliography. 2 vols. H.P. Sims and C.B. Powter

DESCRIPTION: Literature to 1980 pertinent to reclamation in Alberta is listed in Vol. 1 and is also on the University of Alberta computing system. Vol. 2 comprises the keyword index and computer access manual.

NA 7. RRTAC 82-2: A Bibliography of Baseline Studies in Alberta: Soils, Geology, Hydrology and Groundwater. C.B. Powter and H.P. Sims. 97 pp.

DESCRIPTION: This bibliography provides baseline information for persons involved in reclamation research or in the preparation of environmental impact assessments. Materials, up to date as of December 1981 are available from the Alberta Environment Library.

NA 8. RRTAC 83-1: Soil Reconstruction Design for Reclamation of Oil Sand Tailings. Monenco Consultants Ltd. 185 pp.

DESCRIPTION: Volumes of peat and clay required to amend oil sand tailings were estimated based on existing literature. Separate soil prescriptions were made for spruce, jack pine, and herbaceous cover types. The estimates form the basis of recently initiated field trials.

NA 9. RRTAC 83-3: Evaluation of Pipeline Reclamation Practices on Agricultural Lands in Alberta. Hardy Associates (1978) Ltd. 205 pp.

DESCRIPTION: Available information on pipeline reclamation practices was reviewed. A field survey was then conducted to determine the effects of pipe size, age, soil type, construction method, etc. on resulting crop reproduction.

NA 10. RRTAC 83-4: Proceedings: Effects of Coal Mining on Eastern Slopes Hydrology. P.F. Ziemkiewicz. 123 pp.

DESCRIPTION: Technical papers are presented dealing with the impacts of mining on mountain watersheds, their flow characteristics and resulting water quality. Mitigative measures and priorities were also discussed.

NA 11. RRTAC 83-5: Woody Plant Establishment and Management for Oil Sands Mine Reclamation. Techman Engineering Ltd. 124 pp.

DESCRIPTION: This is a review and analysis of information on planting stock quality, rearing site preparation, planting and procedures necessary to ensure survival of trees and shrubs in oil sand reclamation.

NA 12. RRTAC 84-1: Land Surface Reclamation: A Review of International Literature. 2 Vols. H.P. Sims, C.B. Powter and J.A. Campbell. 549 pp.

DESCRIPTION: Nearly all topics of interest to reclamation including mining methods, soil amendments, revegetation, propagation and toxic materials are reviewed in light of the international literature.

** 13. RRTAC 84-2: Propagation Study: Use of Trees and Shrubs for Oil Sand Reclamation. Techman Engineering Ltd. 58 pp.

DESCRIPTION: This report evaluates and summarizes all available published and unpublished information on large-scale propagation methods for shrubs and trees to be used in oil sand reclamation.

* 14. RRTAC 84-3: Reclamation Research Annual Report - 1983. P.F. Ziemkiewicz. 42 pp.

DESCRIPTION: This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results and expenditures.

** 15. RRTAC 84-4: Soil Microbiology in Land Reclamation. 2 Vols. D. Parkinson, R.M. Danielson, C. Griffiths, S. Visser and J.C. Zak. 676 pp.

DESCRIPTION: This is a collection of five reports dealing with reestablishment of fungal decomposers and mycorrhizal symbionts in various amended spoil types.

** 16. RRTAC 85-1: Proceedings: Revegetation Methods for Alberta's Mountains and Foothills. P.F. Ziemkiewicz. 416 pp.

DESCRIPTION: Results of long-term experiments and field experience on species selection, fertilization, reforestation, topsoiling shrub propagation and establishment are presented.

* 17. RRTAC 85-2: Reclamation Research Annual Report - 1984. P.F. Ziemkiewicz. 29 pp.

DESCRIPTION: This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results and expenditures.

** 18. RRTAC 86-1: A Critical Analysis of Settling Pond Design and Alternative Technologies. A. Somani. 372 pp.

DESCRIPTION: The report examines the critical issue of settling pond design and sizing and alternative technologies. An executive summary outlines the findings.

** 19. RRTAC 86-2: Characterization and Variability of Soil Reconstructed after Surface Mining in Central Alberta. T.M. Macyk. 146 pp.

DESCRIPTION: Reconstructed soils representing different materials handling and replacement techniques were characterized and variability in chemical and physical properties was assessed. The data obtained indicate that reconstructed soil properties are determined largely by parent material characteristics and further tempered

by materials handling procedures. Mining tends to create a relatively homogeneous soil landscape in contrast to the mixture of diverse soils found before mining.

* 20. RRTAC 86-3: Generalized Procedures for Assessing Post-Mining Groundwater Supply Potential in the Plains of Alberta - Plains Hydrology and Reclamation Project. M.R. Trudell and S.R. Moran. 30 pp.

DESCRIPTION: In the Plains region of Alberta, the surface mining of coal generally occurs in rural, agricultural areas in which domestic water supply requirements are met almost entirely by groundwater. Consequently, an important aspect of the capability of reclaimed lands to satisfy the needs of a residential component is the post-mining availability of groundwater. This report proposes a sequence of steps or procedures to identify and characterize potential post-mining aquifers.

** 21. RRTAC 86-4: Geology of the Battle River Site: Plains Hydrology and Reclamation Project. A. Maslowski-Schutze, R. Li, M. Fenton and S.R. Moran. 86 pp.

DESCRIPTION: This report summarizes the geological setting of the Battle River study site. It is designed to provide a general understanding of geological conditions adequate to establish a framework for hydrogeological and general reclamation studies. The report is not intended to be a detailed synthesis such as would be required for mine planning purposes.

** 22. RRTAC 86-5: Chemical and Mineralogical Properties of Overburden: Plains Hydrology and Reclamation Program. A. Maslowski-Schutze. 71 pp.

DESCRIPTION: This report describes the physical and mineralogical properties of overburden materials in an effort to identify individual beds within the bedrock overburden that might be significantly different in terms of reclamation potential.

* 23. RRTAC 86-6: Post-Mining Groundwater Supply at the Battle River Site: Plains Hydrology and Reclamation Project. M.R. Trudell, G.J. Sterenberg and S.R. Moran. 49 pp.

DESCRIPTION: The report deals with the availability of water supply in or beneath cast overburden at the Battle River Mining area in east-central Alberta to support post-mining land use. Both groundwater quantity and quality are evaluated.

* 24. RRTAC 86-7: Post-Mining Groundwater Supply at the Highvale Site: Plains Hydrology and Reclamation Project. M.R. Trudell. 25 pp.

DESCRIPTION: This report evaluates the availability of water supply in or beneath cast overburden to support post-mining land use, including both quantity and quality considerations. The study area is the Highvale mining area in west-central Alberta.

* 25. RRTAC 86-8: Reclamation Research Annual Report - 1985. P.F. Ziemkiewicz. 54 pp.

DESCRIPTION: This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results and expenditures.

** 26. RRTAC 86-9: Wildlife Habitat Requirements and Reclamation Techniques for the Mountains and Foothills of Alberta. J.E. Green, R.E. Salter and D.G. Walker. 285 pp.

DESCRIPTION: This report presents a review of relevant North American literature on wildlife habitats in mountain and foothills biomes, reclamation techniques, potential problems in wildlife habitat reclamation, and potential habitat assessment methodologies. Four biomes (Alpine, Subalpine, Montane, and Boreal Uplands) and 10 key wildlife species (snowshoe, hare, beaver, muskrat, elk, moose, caribou, mountain goat, bighorn sheep, spruce grouse, and white-tailed ptarmigan) are discussed.

** 27. RRTAC 87-1: Disposal of Drilling Wastes. L.A. Leskiw, E. Reinl-Dwyer, T.L. Dabrowski, B.J. Rutherford and H. Hamilton. 210 pp.

DESCRIPTION: Current drilling waste disposal practices are reviewed and criteria in Alberta guidelines are assessed. The report also identifies research needs and indicates mitigation measures. A manual included provides a decision-making flowchart to assist in selecting methods of environmentally safe waste disposal.

** 28. RRTAC 87-2: Minesoil and Landscape Reclamation of the Coal Mines in Alberta's Mountains and Foothills. A.W. Fedkenheuer, L.J. Knapik, and D.G. Walker. 174 pp.

DESCRIPTION: This report reviews current reclamation practices with regard to site and soil reconstruction and re-establishment of biological productivity. It also identifies research needs in the Mountain-Foothills area.

** 29. RRTAC 87-3: Gel and Saline Drilling Wastes in Alberta: Workshop Proceedings. D.A. Lloyd (compiler). 218 pp.

DESCRIPTION: Technical papers were presented which describe: the mud systems used and their purpose; industrial constraints; government regulations, procedures and concerns; environmental considerations in waste disposal; and toxic constituents of drilling wastes. Answers to a questionnaire distributed to participants are included in an appendix.

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